

NAVAL POSTGRADUATE SCHOOL
Monterey, California

EC 3550

FINAL EXAM

6/02 Prof. Powers

- This exam is closed book; notes on 6 sides of 8-1/2 x 11 paper are allowed.
- There are four problems; each is equally weighted.
- Partial credit will be given; be sure to do some work on each problem.
- Be sure to include units in your answers.
- Please circle or underline your answers.
- Show *ALL* work.
- Write only your name on these exam sheets.
- Exams and course grades: I will email you an announcement when they are ready. They will be on a small table outside the lab door at the top of the stairs.
- If you want me to send you your exam score and course grade, send me an email request. (This request will waive your privacy rights.)
- Enjoy your break!

Course grade: _____

1		3	
2		4	
TOTAL			

Name: _____

1. Using the vocabulary developed in this course, please provide brief, concise answers to the following questions.
 - (a) What is the primary advantage of single-mode fiber over multimode fiber in a communications link?
 - (b) List three advantages of laser-diode sources over LEDs in fiber links.
 - (c) Consider a fusion splicer used to splice two identical fibers. List the significant factors (i.e., factors with potentially nonzero losses) that determine the loss of the splice.
 - (d) Describe the "avalanche process" that occurs in an APD.
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2. Short problems . . .

- (a) Consider a step-index fiber with $a = 3.0\mu\text{m}$, $n_1 = 1.450$ and $\Delta = 0.9\%$. How many modes will it have at 1550 nm?
 - (b) A graded-index single-mode fiber has $a = 3.0\mu\text{m}$, $n_1 = 1.450$, $\Delta = 0.9\%$ and $g = 1.96$. Find its cutoff wavelength.
 - (c) A laser diode has a predicted operating life of 10 years at 300K. Assuming that its activation energy is 0.7 eV, what is its predicted operating life (in years) at an operating temperature of 310K?
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3. Consider the digital optical link shown in Fig. 1, operating at 1300 nm with a bit rate of 2.5 Gb/s.

- (a) The optical receiver consists of a pin diode (responsivity = 0.940 A/W at 1300 nm), a load resistor (75Ω and a noise temperature of 375K), and a preamplifier (gain = 10^3 and noise figure of 3.5 dB). The desired BER of 10^{-10} requires that $Q = 6.36$.

Find the value of the minimum power (*in both watts and dBm*) required at the receiver to achieve this BER at this bit rate. Assume that the thermal noise is dominant over all other noise sources.

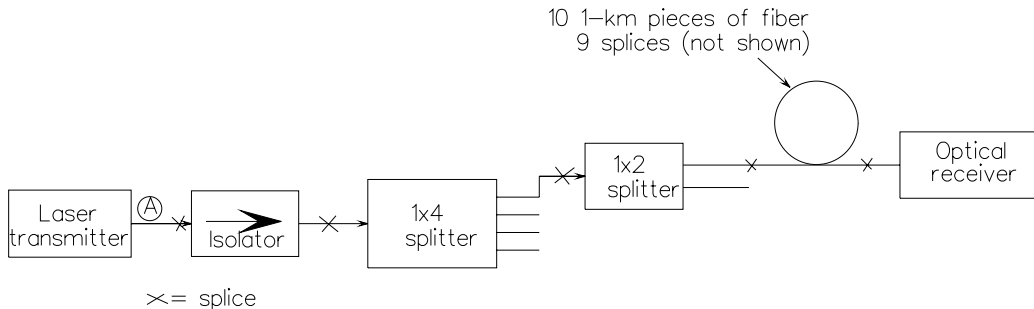


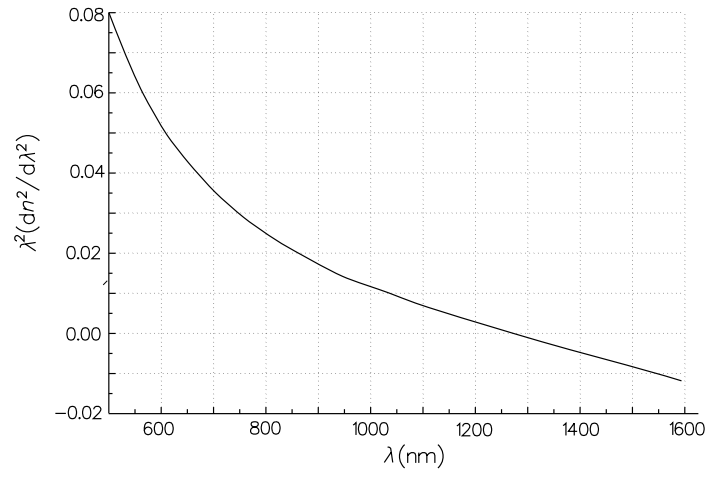
Figure 1: Fiber Link of Prob. 3.

- (b) The parameters for the components of the link are shown in the tables below. The loss in the long pieces of fiber is 0.7 dB/km. (Unless specified, all other losses [e.g., losses in fiber pigtails] are negligible.)

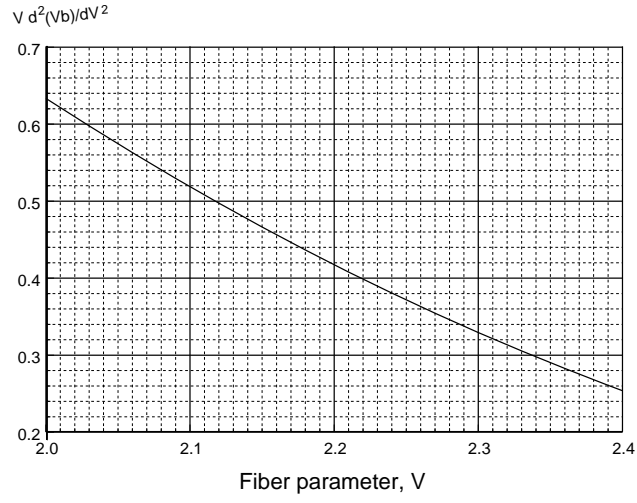
Using the “dB method” and your result from part a, calculate the required power in the fiber at point ”A” *in both dBm and watts*.

Splice parameters		Isolator parameters		Splitter parameters	
Parameter	Value	Parameter	Value	Parameter	Value
Insertion loss	0.15 dB	Insertion losses	2.2 dB	Excess loss	0.7 dB
Return loss	25 dB	Isolation	25 dB		
		Return loss	30 dB		

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4. Consider an optical-fiber amplifier operating at 1555 nm with the following properties: $n_{sp} = 1.3$, optical filter spectral width = 1.2 nm, saturation power of 9 mW, and an unsaturated gain of 32 dB. If the measured ASE power of the amplifier is 40 microwatts, what is the power at the amplifier input?
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(a)



(b)

Figure 2: (a) Fig. 3.8 and (b) Fig. 3.10 of text.